THE PATHOLOGY OF FRACTURE OF THE LOWER EXTREMITY OF THE RADIUS.

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It is eighty years since Colles described the fracture that bears his name, and yet there seems no end to the literature on the subject. But in spite of, or because of, this wide discussion, there seems still something to be said on the pathology of the injury, less new, perhaps, in fact than in point of view. Now that the use of the X-ray has stimulated interest in the study of detailed lesions in fractures, now that we are enabled by means of skiagraphs to know, in a given case, something both of the clinical symptoms and of the detailed lesions, we are in a position to review the old evidence intelligently and to combine it with the new. The older notion, of a typical fracture of the base of the radius recurring from case to case with constantly recurring details, has long been untenable. The problem as it is, is to classify, so far as may be, the varying lesions which occur in wrist fractures, and to look this classification over to see if it cannot be made to help out an intelligent treatment and a more accurate prognosis.

There is no real lack of data for this study of lesions.

It is not to be forgotten that there are many recorded autopsies of cases with wrist fractures, a fair number of anatomical examinations made possible by operations, many museum specimens, including not a few recent ones, and a great mass of experimental evidence, which is of some value for confirmation. Valuable as the X-ray is, it is obviously not the best basis for scientific classification of lesions. It will not do to base conclusions as to details on it alone.

In the past, conclusions drawn from the examination of actual specimens have been somewhat discredited: united fractures are surely somewhat uncertain and admit of a varying interpretation. It has been held that no conclusions are to be drawn from most autopsy specimens,—coming from individuals dying of other injuries received with the wrist fracture, they have been supposed to represent the effects of excessive trauma and to bear no necessary relation to the lesions of the cases commonly seen clinically. In actual fact, however, there are not a few instances where the opportunity for an autopsy was dependent on an intercurrent pneumonia or other infection, and not directly a result of the accident. Yet examination of the records of these particular dissections shows no essential difference from the conditions in other autopsies, and the study of skiagraphs of wrist injuries proves that extensive and complicated bone lesions are by no means unusual or atypical. It may be said in advance that there seems to be no single form of lesion described from any actual specimen, which is susceptible of demonstration in the shadow-picture, that has not been so demonstrated in one or more clinical cases; nor has the X-ray discovered any previously undescribed lesions.

It would seem worth while, then, to study in detail the lesions found in dissected specimens, using the skiagraph and the experimental evidence as a verification only. It needs no argument to show that the X-ray plate, valuable as it is, is in many ways a rather imperfect record.

From this point of view, then, this paper has been prepared, based essentially on such specimens as have been available for examination, on descriptions and plates of other specimens, on autopsy reports, on cadaver experiments by the writer, and on other such experiments found recorded. Many skiagraphs have been examined as a check on the conclusions reached.[1] There proved to be available for the purpose in hand a considerable number of specimens, plates, and descriptions, representing in all some 180 to 200 preparations.[1] Of these, sixty[2] represent reports of autopsies, specimens obtained by amputation, resection, or other operations, and specimens of ununited, or at least *recent,* fractures in the various museums.

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[1] The cases of which skiagraphs are used for illustration, and most of the other cases cited clinically, were seen at the Boston City Hospital while the writer was Acting Out-patient Surgeon.

The definition of Colles's fracture is not an altogether rigid one; the fracture as originally described cannot be taken as a hard and fast type, nor can we hold to wrist fractures with a given cause. A fall on the hand is responsible for the vast majority of cases; but even in cases seen clinically a clear history is often unobtainable, and there is good reason to believe that other forms of trauma may give very similar lesions.

For the purpose of study it may be well to include under Colles's fracture all those fractures of the radius which occur within a couple of inches of the wrist-joint.

All these fractures have certain characteristics which are, broadly speaking, constant,—the proximity to the joint, the displacement and rotation of the lower fragment upward, backward, and outward, the forward displacement of the ulna, etc. The variations from this type which occur bear no obvious relation to the variations in the detailed bone lesions, however, and a broad grouping is hardly possible.

It will, perhaps, best serve to take up one by one the single lesions or items, so to speak, which go to make up the fracture as a whole, then later to reconstruct from these the more usual combinations occurring. First as to

Height above the Wrist-Joint.—Colles himself described a fracture an inch and a half above the joint. This is obviously too high. The exact height is not altogether easy to fix on, for few specimens show a fracture either accurately transverse or in a single plane. In thirty-nine museum specimens, however, the average measurement was .68 inch above the joint. Twenty-one X-rays measured by the writer from plates taken without selection gave an average of five-eighths of an inch. A large proportion of these twenty-one came very near this average; that is to say, the run of the cases show a height of from one-half to one inch, those higher or lower being far less frequent.[1]

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[1] The exact number cannot be given because of some duplicating of descriptions. Smith, Cameron, Callender, Bennett, Gordon, Lucas, Hutchinson, and D'Arcy Power have covered something the same ground in the English museums, and, owing to the changing of catalogue numbers, clear distinction as to actual specimens is not always possible.

[2] Not including the epiphyseal separations.

Direction of the Fracture-plane.—It was formerly held that an oblique fracture running up and back was the typical form, but Voillemier drew attention to the frequency of transverse fractures among those occurring within an inch of the joint, while R. W. Smith drew attention to the possible error in estimating obliquity from united specimens.[2] He says, "I have examined upward of twenty specimens of the injury, and have not found one in which the bone had been broken

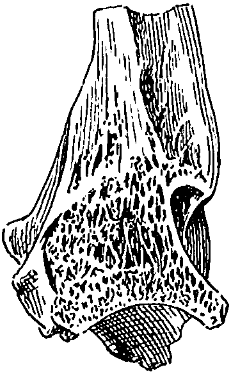

FIG. 1.—United fracture; displaced backward; depression at back filled up with new bone. Warren Museum, No. 5194.

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[1] The height given by various authors is from one-quarter inch to one and a half, more often one inch, or under. Albert gives a minimum of five milligrammes, Smith of one-quarter inch. Hamilton gives as the maximum one and a half inches, reaching the height set by Colles. Smith in twenty-three cases found none over one inch from the joint.

[2] This error arises from the filling up with new bone of the hollow left posteriorly and, it may be, externally above the lower fragment. This new bone merges in with the lower fragment, and, as it is above the fracture line posteriorly, must necessarily give the appearance of an increased obliquity. (See Figs. 1 and 2.)

with any considerable degree of obliquity." Gordon, on the other hand, found only eight out of twenty-seven specimens examined to be really transverse.

The question is involved, not only on account of the difficulty of interpreting united specimens, but because there is no standard as to what shall be called oblique; for instance, the twelve specimens in the New York Hospital Museum have been reported on by three different observers: Hamilton classes eight as oblique up and backward; Satterthwaite says nine are transverse; Pilcher classes eleven of the twelve as transverse. Of the reported autopsies and ununited specimens where this point is settled, thirteen are transverse or nearly so, seven definitely oblique up and backward.

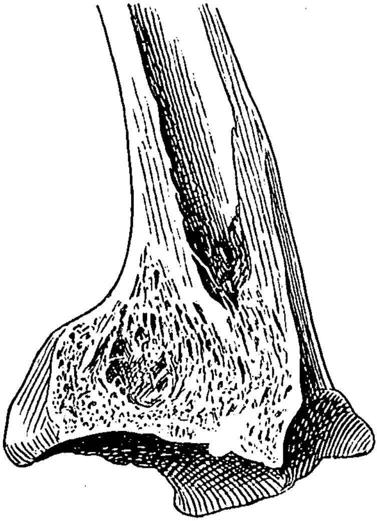

FIG. 2.—United fracture; displacement upward and outward; shows the "impaction line." Warren Museum, No. 1040.

As to X-rays, the only view which gives definite data on this point—the lateral view—is unfortunately usually neglected. The impression the writer has gained, however, from this view in both published and unpublished plates, is that any considerable degree of obliquity is exceptional.

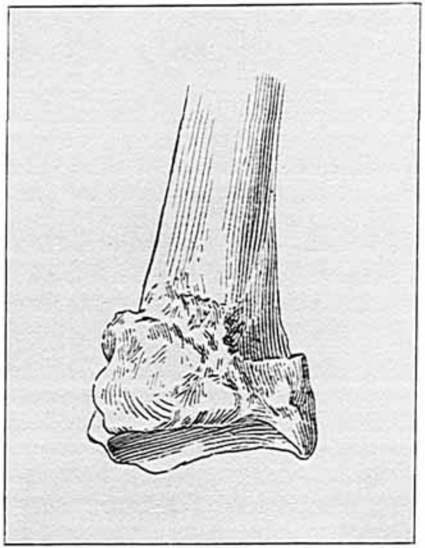

Fig. 3.—Old fracture united with but little displacement; much excess of bone formation at seat of fracture.

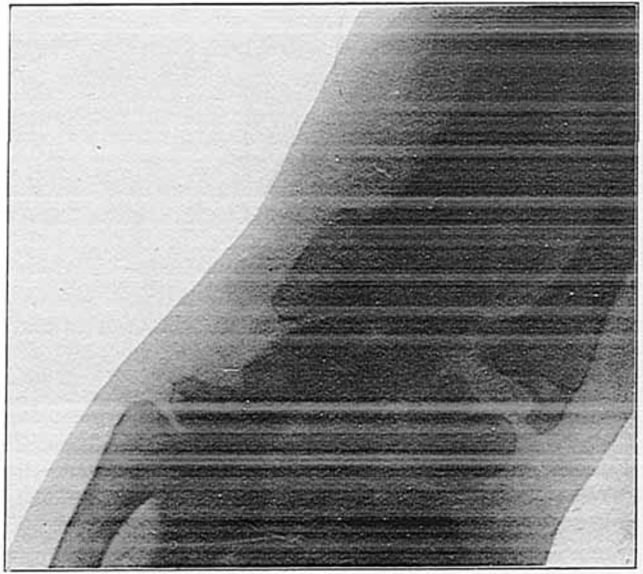

Fig. 4.—Fresh case of fracture: fracture transverse, with some displacement upward: partial fracture of ulnar styloid at its base.

Obliquity of the fracture line from side to side is usually in the form of an upward and outward trend. This is not infrequent. The trend upward may increase considerably near the outer edge of the bone, or a transverse fracture may trend upward at this point. As a rule, the obliquity is but slight. Smith says "always trifling" but well marked oblique fractures do occur.

Obliquity in the reverse direction is much rarer; here, too, the slant is usually trifling.

Obliquity from side to side in either direction is not necessarily associated with obliquity in an anteroposterior direction.

Not infrequently one finds a well-marked concavity of the fracture surface of the lower fragment as a whole, a point to which Lecomte long since called attention. Often there is a line of fracture running towards the joint from the convergence of the two slopes, so that the posterior view gives a Y-shaped pattern of fracture lines.

No point in relation to the fracture has been more discussed than that of impaction. Many surgeons have held impaction an essential feature of the fracture, but there has never been any good ground for this view.

Smith long since showed that the "impaction line" seen in section in so many museum specimens and relied on by Voillemier, Cameron, and others (see Figs. 1 and 2), is no proof of interpenetration of fragments, but may represent inclusion of the broken end, especially of the posterior edge of the upper fragment, in the permanent callus. Judgments as to impaction based on examination of united fractures are therefore practically worthless.

There are, however, autopsies and recent specimens enough to throw light on the question.

In the following cases examination showed definite impaction[1] of varying degree:

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[1] The usual form of impaction, where it occurs, seems, according to Bennett's studies, to be the reciprocal, in which the upper fragment penetrates the lower posteriorly; anteriorly the lower is driven into the upper, or there may be a hinging with impaction of the upper into the lower at the back, at the front no penetration at all.

Callender, autopsy; Callender, Middlesex Hospital Museum, no number; Callender, Middlesex Hospital Museum, I, 23a; Callender, St. Bartholomew Hospital Museum, C, 136; McGraw and Walker, autopsy; Hamilton, autopsy;

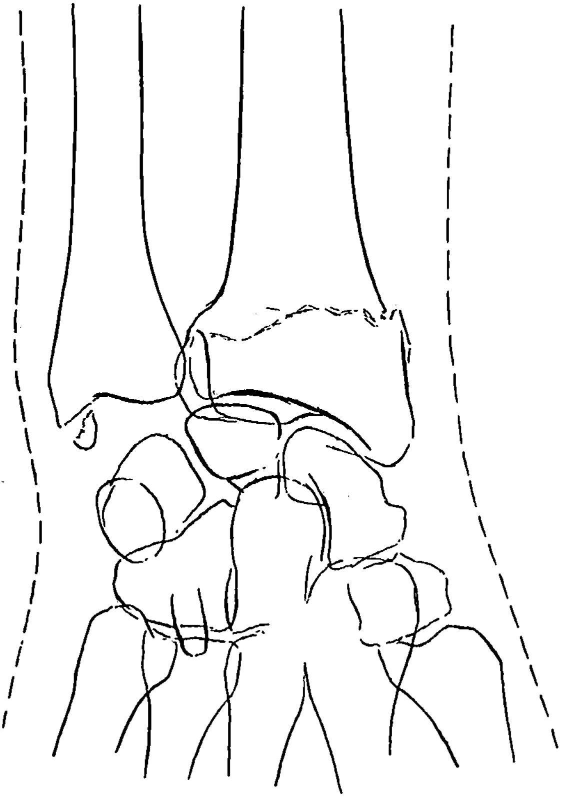

FIG. 5 (Tracing from X-ray).—Transverse fracture of the radius, with little displacement; fracture of ulnar styloid.

London Hospital Museum, recent specimen; Cameron, Glasgow Royal Infirmary Museum, II, 182; D'Arcy Power, St. Bartholomew Hospital Museum, III, 925a; D'Arcy Power, St. Bartholomew Hospital Museum, III, 925b.

On the other hand, there are plenty of autopsies to show the possibility of fractures, simple or comminuted, without any impaction whatever. All the following are authentic cases by competent observers:

Couper and Hutchinson, autopsy; Cameron (autopsy), Glasgow Royal Infirmary, II, 172; Callender, St. Bartholomew Hospital Museum, recent specimen; Moore (autopsy, case Tumey, both wrists unimpacted); Hamilton, autopsy; Smith, fresh specimen, his Case I; Jones, autopsy; Maisonneuve (described by Malgaigne, plate given by Stimson, apparently same case as cited by Schmit from the *Gazette des Hôpitaux*); Warren Museum, Specimen 8117. (Fig. 7.) Hutchinson says that he has seen dissections of seven or eight recent cases, in all of which there was more or less lacking, but in none any real impaction.

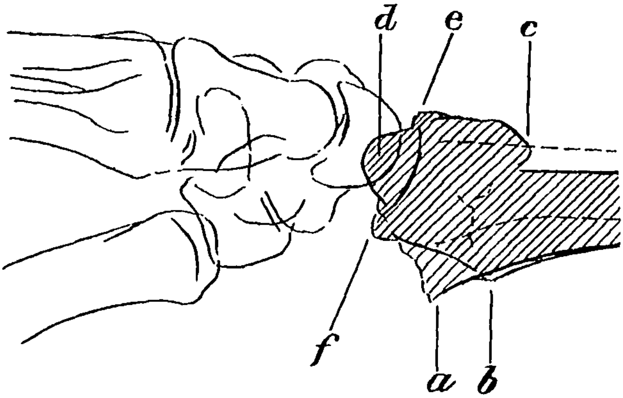

FIG. 6 (Tracing from X-ray plate).—Transverse fracture of the radius; some backward displacement; much rotation backward. The ulna is shown in dotted line; *a*, *b*, lower end of radial shaft; *c*, back edge of lower fragment; *d*, styloid process of radius; *e*, *f*, articular surface of radius rotated backward.

The fact noted by Pilcher and others explains certain cases that clinically appear impacted; this is, that in many cases the posterior periosteum is more or less stripped up, but remains untorn and forms a strap that helps lock the fragments in place.

Muscular tension undoubtedly plays a part as well, and the autopsy reported by D'Arcy Power, where the slight displacement of the fragments could not be reduced until after division of the tendons of the carpal flexors, the extensors of the thumb, and the supinator longus, shows how effectual the resistance of even dead muscles may be. So, too, the autopsy of the Couper-Hutchinson case, where reduction was

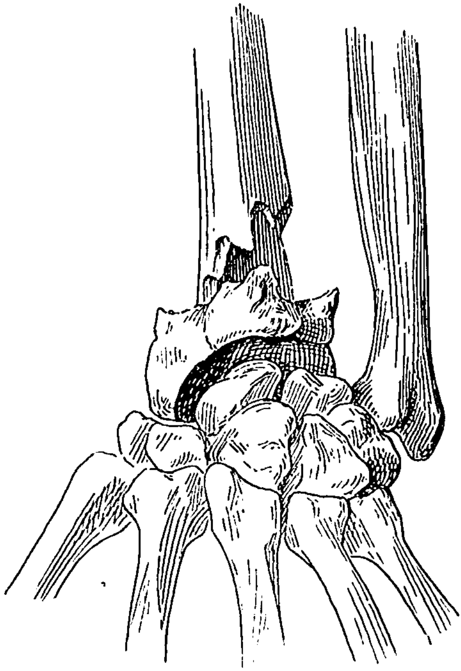

FIG. 7.—"Amputated three inches above condyles for compound Colles's fracture, with rupture of radial artery and subsequent spreading gangrene." (Specimen of Dr. J. C. Warren.) A projecting spur anteriorly caused arterial injury, the fracture transverse, with loss of substance and with considerable backward displacement; lower fragment comminuted at back and ulnar side. Warren Museum, No. 8117.

possible only after most of the wrist tendons had been divided. Here the deformity is said not only to have been maintained, but also produced by the post-mortem rigidity, not appearing until after death.

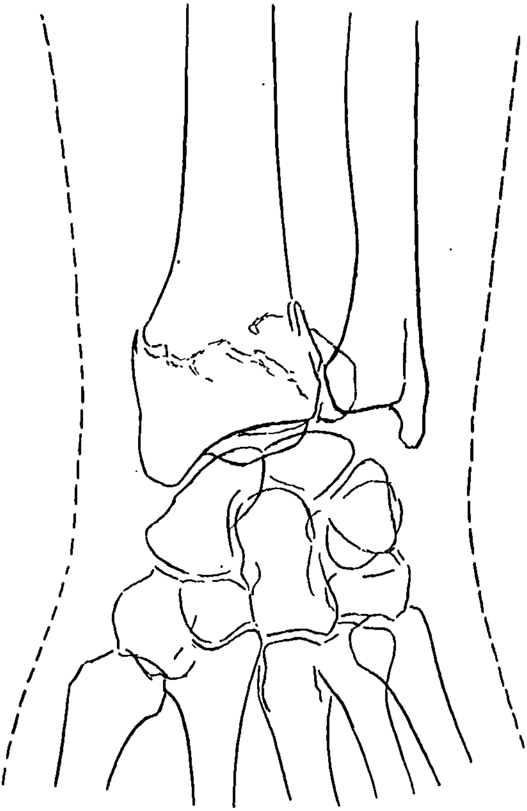

FIG. 8 (Tracing from X-ray).—Comminuted transverse fracture of the radius; slight rotation up and outward.

The firmness of retention after reduction is a measure of the action of these forces, and it is undoubtedly for these reasons that so many cases seem clinically to be impacted. It is to be borne in mind that the familiar change of relation in the height of the two styloid processes is no sign of impaction, even in the absence of marked lateral displacement. The rise of the radial styloid may show rotation up and outward as well as shortening. The actual shortening when present is under one-half inch, usually much less, and may be due not to impaction but to simple crushing and actual destruction of bony tissue, particularly apt to occur at the back.

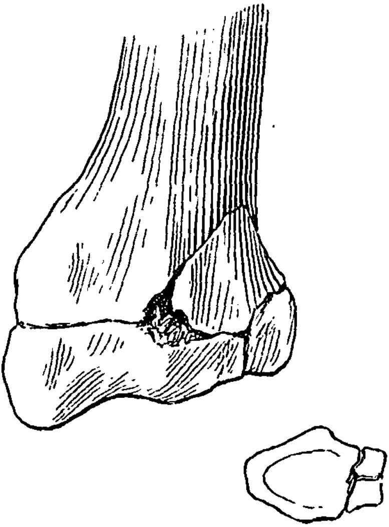

Fig. 9.—Transverse fracture; lower fragment comminuted at ulnar border; piece split off from upper fragment at ulnar side of the dorsal surface. Result of direct violence. Warren Museum, No. 1038.

Impaction does not seem to be associated especially with any especial form of the fracture, nor does it seem to stand in any necessary relation to comminution. A comminuted fracture may still be impacted and a simple fracture may show no trace of impaction. It goes without saying, of course, that totally irregular smashing of the radius precludes any impaction.

It is to be remembered that shortening of the radius does not necessarily mean impaction, and the usual clinical measurement of height of radial styloid and ulnar head tells one nothing as to the exact form of fracture. Shortening may result from displacement of comminuted fragments, from displacement of an entire lower fragment upward, especially in oblique fractures, or from rotation backward or outward.

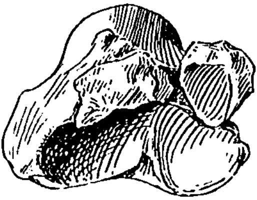

FIG. 10.—No transverse fracture, but separation of the fragments from the posterior edge of the joint surface. Result of direct violence. Scaphoid also fractured. Warren Museum, 3776.

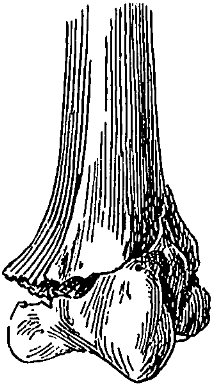

FIG. 11.—Epiphyseal separation; left radius showing external and anterior surfaces. Warren Museum, No. 6212.

Such rotation is possible not only by impaction but by crushing of bony tissues as well, and it seems to be common enough to have such crushing that a gap in the bone is left after reduction.

X-ray evidence has been cited to show impaction, but it can be said that most plates so cited really show nothing in the matter, and that the X-ray can hardly give us information on this point.

How frequently impaction occurs we cannot yet say; it certainly is not constant enough to be regarded as typical. It is definitely established that it may or may not be present; it is certainly less frequent than clinical examination would lead one to suppose.

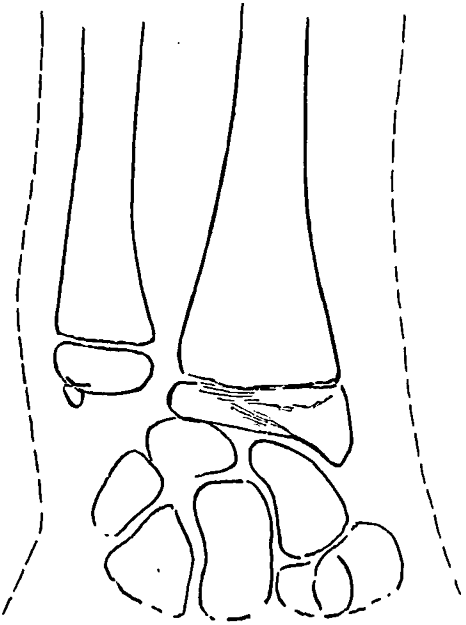

FIG. 12 (Tracing from X-ray).—Separation of the epiphysis of the radius, not now displaced; comminution of the epiphysis; fracture of the ulnar styloid at its base without displacement.

Displacement.—There may be no displacement at all, even if the fracture is comminuted, as in an autopsy by Callender. There may be displacement *in toto* and a rotatory displacement as well.

The usual type shows a displacement *in toto* of the lower fragment backward and upward with a rotation backward, so that the articular surface looks not down and forward, but down and back. (See Fig. 6.) Backward displacement without any notable rotation may occur. (Smith, Case I.)

Rotation back and up does occur with little or no displacement of the fragment *in toto.* Moore (Tuney), Cameron (II, 182), and Callender (St. Bartholomew Hospital Museum, III, 78); but it is possible only by impaction or a considerable actual destruction of bone tissue (such destruction of tissue is shown in plate of McGraw and Walker's case; it may, of course, be far more extensive).

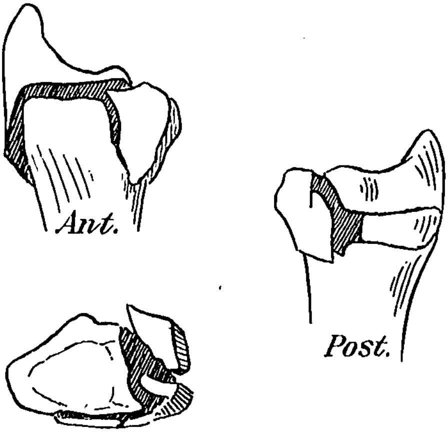

Fig. 13.—Fracture oblique up and backward; irregular comminution (after Rutherford).

Such rotation may of itself determine a considerable shortening apart from any dislocation of fragments.

Displacement of the fragment outward in some degree is a usual feature[1] and may occur with little backward displacement, as shown in the plate given by Smith of his Case XIII, also Callender (Museum University College Hospital, C, 4265), and rotation upward and outward is to be noted in most specimens. (*E.g.*, Warren Museum, 1040.) (Fig. 2.)

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[1] This displacement, obvious and frequent in museum specimens, is, curiously enough, disputed by Kahleyss; though his plates show two good instances of it. One of these he admits as an exception (Taf., vi, vii, 4a); the other (Taf., vi, vii, 7) he ignores.

The rotation outward has been supposed to give an encroachment on the interosseous space,[1] but Gordon found this encroachment but slight where it occurred at all, and the actual fact would seem to be that there is more often a separation of radius and ulna—a diastasis—of the radio-ulnar joint, which would leave this space free in any case. This diastasis is obvious in certain X-rays published by Don and by Beck, and in various others seen by the writer. Fig. 5 shows this in slight degree.

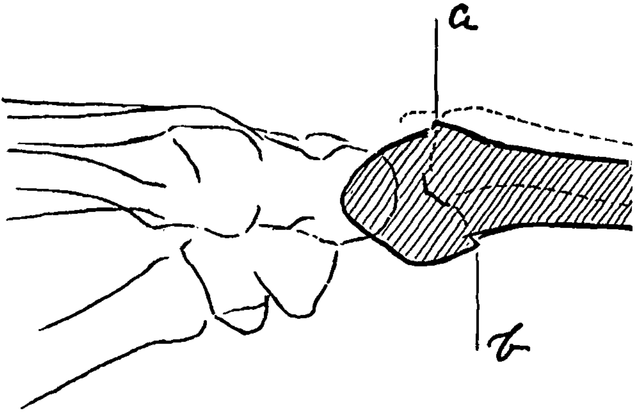

FIG. 14 (Tracing from X-ray).—Fracture of radius up and forward, with slight anterior displacement; backward displacement of the ulna (shown in dotted line), *a*, lower end of upper fragment, overlapping; *b*, upper end of lower fragment, overlapping.

Displacement forward with rotation upward and forward is seen in the so-called reversed Colles: it is very rare. (Fig. 14.)

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[1] Plates 25 and 26, in Roberts's monograph, of a specimen in the Museum of the Royal College of Surgeons in Ireland, show this encroachment in a marked degree.

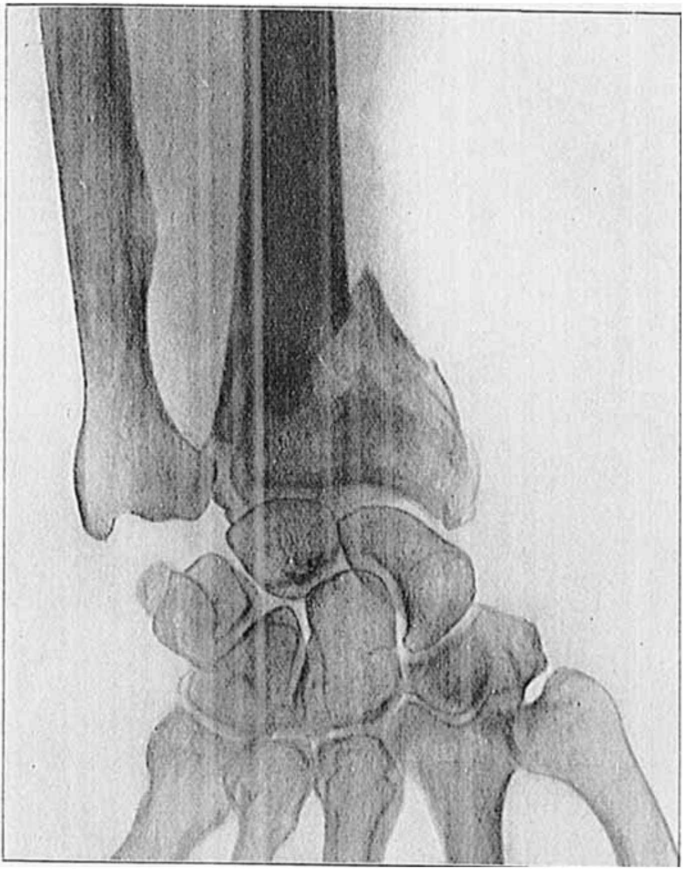

FIG. 15.—Fresh fracture of radius, oblique up and outward; much outward, some upward displacement; moderate rotation of lower fragment; fragment freely movable under ether.

Displacement inward is likewise a rarity, and is slight in extent when it occurs. Smith speaks of such a case (No. VII), also Callender (recent specimen Middlesex Hospital Museum, no number). Picard's Plate II also shows this displacement.

Beside these displacements, a rotation of the lower radial fragment on its long axis is alleged,—a rotation carrying the radial styloid backward. Cases and specimens by Callender, Middlesex Hospital Museum, I, 22c; Callender, St. George Hospital Museum, I, 93; Westbrook, autopsy; Smith (Case XI, Museum Royal College Surgery, Ea, 693; Smith, Case XIII, Museum Peter Street School of Medicine).

This rotation is slight when it occurs. The contrary rotation may occur (specimen, Warren Museum, 6296).

The various displacements and rotations occur in much the same way in comminuted as in simple fracture. Sometimes the pieces of the comminuted lower fragment are widely separated, but more commonly they are more or less closely held together by ligaments and periosteum, and are displaced together practically en masse. (Figs. 7 and 8.)

Lines of Fracture.—The most striking feature found in studying the detailed data of wrist fractures is the variety of lesions. These various possible features of the fracture will first be considered separately.

I. *Simple Transverse Fracture.*—This is a fracture across the full width of the bone, approximately horizontal, with an occasional tendency to trend up and back and up and outward. This is the form to which Voillemier first called attention, and has been accepted by Smith and others as typical. (See Figs. 3, 4, 5, and 6.)

Such fractures may occur at any point from within one-quarter inch above the joint up to an inch and a half or more. In a large proportion of the cases, however, the fracture lies about one-half to three-quarters of an inch up.

Autopsy reports of fresh cases or recent specimens of this class are recorded by Smith (Case I), autopsy; Callender, Museum London Hospital, recent specimen, and in a second case (autopsy); Moore (autopsy, Tumey); Schmit (recent specimen described in *Gazette des Hôpitaux*); Maisonneuve (recent specimen described by Malgaigne).

There may (as in both Callender's cases noted above) be impaction with this transverse form, or it may be absent as in Smith's case (Case I).

There may be no displacement whatever, or extreme backward displacement and backward rotation as in Moore's case (Moore, case, Tumey), where the broken surface of the lower fragment rested on the periosteum of the upper.

Backward displacement in some degree is rarely absent. The same may be said of the backward rotation; but Smith gives a plate of a specimen with displacement directly backward without any rotation at all. There is usually some displacement and rotation of the lower fragment outward; considerable displacement outward may occur without rotation, as shown in the plate given by Stimson of the Maisonneuve specimen and in a specimen figured by R. W. Smith (his No. XIII, Museum Peter Street School of Medicine).

II. *Comminuted Transverse Fracture.*—The fracture may be in all respects similar to the form just described, save for the complication of fracture lines through the lower fragment into the joint. There is not necessarily any separation of the bits of the lower fragment. (Figs. 7, 8, and 17.)

Such cases are frequent and not necessarily the result of great violence. Hutchinson says that of seven or eight dissections of fresh cases that he has seen, all were comminuted. Bennett found twenty-three comminuted in fifty-four specimens examined, D'Arcy Power twenty-six out of forty-eight. Of five ununited specimens in the Warren Museum there is comminution in all.[1] Probably these figures show a larger proportion than in the run of clinical cases, and a comminution often of severer type, as they represent in a large proportion of cases the results of severe trauma, and inevitably include more or less cases due to direct violence.

Among autopsies and recent specimens of this class are the following: Cameron, Museum Glasgow Royal Infirmary, II, 182; McGraw and Walker, autopsy; Callender, Middlesex Hospital Museum, I, 23a; St. Bartholomew Hospital Museum, III, 125; St. Bartholomew Hospital Museum, C, 136; Specimens in Warren Museum, Nos. 8117 and 1038; Wight, autopsy; Stimson, autopsy; Moore, autopsy (case Huntington); D'Arcy Power, New Museum Cambridge, no number; St. Bartholomew Hospital Museum, III, 925a; St. Bartholomew Hospital Museum, III, 925b; St. George Hospital Museum, 3423b.

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[1] This does not include a simple separation of the epiphysis.

The lines of the penetration into the joint cannot be called constant, but certain lines to which Bennett called attention recur frequently. These he describes as follows: " A fissure starting from the same point in the ulnar facet, runs into the carpal articular cartilage, along its posterior edge, breaking out into the dorsal surface of the bone and then, in the least extensive injuries, at the outer side of the common extensor groove, or in others running along as far as the groove for the radial extensors, and in a few breaking out at each of these positions." (See Figs. 7, 8, 13, and 17.)

This line he found alone in ten of twenty-three comminuted specimens (in a series of fifty-four fractures, mainly museum specimens, but including his two autopsy cases); in six others joined to a branch from this fissure towards the anterior portion of the scaphoid facette. Of all his twenty-three comminuted cases only one showed other than these lines.

The specimen of McGraw and Walker (Fig. 13) shows these lines in the fresh specimen. Similar cases in this respect are three described by D'Arcy Power, so far as can be judged from his descriptions, the two autopsy specimens, St. Bartholomew Hospital Museum, 925a and 925b, and the specimens St. George Hospital Museum, 3423b; so, also, the specimen in Warren Museum, 8117. (Fig. 7.)

In some cases, however, the line of penetration into the joint is anterior-posterior, the lower fragment is split, usually through the scaphoid facette, into two portions. Such cases are reported by Westbrook, Wight, and specimen in St. Bartholomew Hospital Museum, 931 and 932, cited by Poland. (See Fig. 18.)

Not infrequently there is an inconsiderable chipping off of an edge of the articular surface, usually the posterior. So No. 955 of the Hunterian Museum described by Power.

In other cases there is no typical arrangement of lines at all; there is either a comparatively simple arrangement deviating from those just described, as in Stimson's case where two crossed lines divided the articular surface in four pieces, or as in Hunt's (see Fig. 20); or there may be simply shapeless comminution of the whole lower portion of the bone as in the specimens numbered 1002, 1042, and 3693, in the Warren Museum, and in a number of the described autopsies and specimens.

In the majority of cases there is relatively little separation of the portions of the lower fragment; they may be held together by periosteum and not to be separated at all, the fracture being but a thin fissure, not necessarily obvious from the joint side. Such a condition as this is relatively frequent in experimental fractures, and is probably frequent enough clinically in cases where the X-ray may not show it. D'Arcy Power describes such a specimen (St. Mary's Asylum College, 136) and a second (St. Bartholomew Hospital Museum, 926), where the comminution, as he says, has so healed as to leave but a line on the joint side. Cameron's specimen (Glasgow Royal Infirmary Museum, II, 182) also showed a lower fragment, split in three, firmly held by periosteum.

III. *Separation of the Radial Epiphysis.*—This may be looked for up to the age of eighteen or nineteen years, though Voillemier instances two cases where the consolidation of this epiphysis with the shaft was delayed to the age of twenty-four and twenty-five years respectively. The most usual age for this lesion is between twelve and eighteen years. The lesion is much the same in most cases; but the distinction can be broadly drawn that pure epiphyseal separations occur especially in younger children, while the lesion in older patients is more likely to be anteriorly a separation in the epiphyseal line, while posteriorly the line of fracture trends upward; this may result simply in the removal of a sliver of bone (see Fig. 11), or the wedge above the epiphysis carried away with it may be of considerable size.

This lesion has been most carefully studied by Vogt, Bruns, Di Paoli, Bennett, and lately in the wonderfully complete monograph on epiphyses by Poland. Clinically, the injury is far less common than Colles's fracture, but opportunities for study have been many, for a very large proportion of cases are compound, and many deaths from sepsis and many amputations swell the list of specimens. Moreover the injury seems to be, in larger degree than Colles's fracture, a product of severe trauma, and is relatively often found in children dead from severe falls. In all there are sixty specimens of which accurate examinations are at hand. These include, according to Poland, fourteen compound cases, and this list seems not to include the case of Lehmann (cited by Roberts). These cases seem all to have been compound anteriorly, the radius protruding in some, sometimes complicated with a wound made by the ulna, in others the ulna alone has protruded.

The displacement has usually been backward, much as in Colles's fracture, and may be extreme, as in the specimen from the Royal College of Surgeons Museum, 956c, of which Poland gives a plate. In these cases especially, and in a large proportion of all cases, the periosteum, torn in front, is stripped up posteriorly, as often in true Colles's fracture (*e.g.*, specimen 758b in St. Bartholomew Hospital Museum, with a stripping up of one and one-quarter inches); this stripping up seems in fact more usual in the epiphyseal cases. There is little tendency to lateral displacement in these cases, much less than in true fracture.

Forward displacement seems not very unusual. Poland cites five instances, and the cases of Lehmann and of Wight, quoted by Roberts, seem authentic.

The damage to the radius varies, as has been said, in the amount of diaphysis carried away with the lower fragment, and in the presence or absence of comminution. Specimens described by Callender (two), by Bennett, and by Dolbear showed this, and the appended X-ray (Fig. 12) shows this splitting through the thin portion of the epiphysis. As the thickness at the centre is only some five-sixteenths inch in the full-grown bone, this occurrence is not surprising.

The damage to the ulna with the radial separation is not constant, but frequent enough. The ulna may be fractured (Hilton, Lehmann, Bruns), or its epiphysis may be separated (Di Paoli, plate by Poland); Bruns, three cases; or there may be a separation of the ulnar styloid (autopsy by Shattock, case of Wight, and St. Bartholomew Hospital Museum, 758B; Royal College of Surgeons Museum, 956C; Guy's Hospital Museum, No. 587; St. George's Hospital Museum, 3424, 114b).

This lesion is also shown in the X-ray plate, Fig. 12. The luxation of the ulna occurs much as in Colles's (Moore, Di Paoli).

Johnston gives a case of tearing of the internal lateral ligament.

The triangular fibrocartilage may give way, as in the fracture (specimen 956B in Royal College of Surgeons Museum, and in an autopsy by Moore).

Most interesting of these epiphyseal separations are those without displacement and the partial separations. Of the latter class D'Arcy Power described a dissected specimen, and since the study of these lesions with the X-ray has attracted attention to them, many clinical cases are to be found. They give the signs of local damage and sometimes mobility; the X-ray shows almost nothing.

As has been said, the complete separations are usually the result of falls, and usually (according to Di Paoli in 19 of 35, according to Poland an even larger proportion, 38 of 40) from falls on the palm. Falls on the palm in young patients with unconsolidated epiphyses, where the trauma is less, seem curiously enough to lead either to fracture above the epiphyseal line (see Fig. 16) or to a simple springing and wrenching of the epiphyseal line, evidenced by extreme well-localized tenderness, and by an appearance in the skiagraph of a slight widening of the line (not constantly present and likely to be obvious at one side only). There is rarely a fracture of the styloid of the ulna. Apart from the specimen cited, there seem to be no anatomical data as to these cases, which are frequent and need farther study.

The shortening resulting from the epiphyseal separation, though well attested by eighteen recorded cases, seems not to be usual, occurring but twice in thirty-two cases seen at the time of the injury and followed up. The shortening, when present, may be extreme, as in a case of Hutchinson's, where it amounted to two and one-quarter inches.

Whether it bears any definite relation to extent of displacement, to extent of comminution, or to improper reposition, is yet to be settled.

IV. *Fracture Oblique Upward and Backward.*—This, once supposed the typical form of Colles's fracture, is probably, unless one regards the very slight grades of obliquity, less common than the approximately transverse forms.

The difficulty of judging united specimens in this regard has been dwelt on, and even with the X-ray only the often neglected lateral view can decide this point.

Fresh specimens of this type from autopsies are described by (1) Couper-Hutchinson; (2) Löbker; (3) Cameron (Glasgow Royal Infirmary, II, 172); (4) Rutherford (autopsy); (5) Moore (Tumey, autopsy); (6) Bulteau (specimen I), autopsy; (7) Bulteau (specimen II), autopsy; (8) McGraw and Walker, autopsy.

The specimen described by Packard (Museum New York Hospital, 130) and the specimens in the Warren Museum, 5194 and 1040 (and a new unnumbered specimen), though not fresh, are convincing as to obliquity.

The fracture, at any angle of obliquity, may be combined with any slope upward and outward. Like the transverse fractures, many of these are comminuted (as Nos. 3, 4, 6, 7, and 8 of the above list).

The patterns of comminution—the lines of joint penetration—seem in no way different, so far as recorded, from those described for the transverse fracture. Either the lines described by Bennett occur (he does not, in his description, separate the transverse from the oblique forms in this regard), or the anteroposterior split (shown in the case of Rutherford, for example) may occur.

As a subclass of these fractures oblique downward and forward are to be reckoned the so-called Barton's fractures, oblique downward and forward, but running only from the posterior surface down and into the wrist-joint, not reaching the anterior surface.

There seems no doubt that the cases on which Barton based his description were of simple Colles's fracture; but the fracture he supposed to exist in these cases has actually occurred, though it is very rare. The only specimens of which there is any accurate record seem to be those of Neill (plate in Agnew's Surgery, Vol. i, 905); Lenoir (quoted by Voillemier); Flower (Middlesex Hospital Museum, autopsy); Warren Museum, No. 3776. (Fig. 10.) As to the clinical occurrence of this lesion, the writer has seen no case, nor any skiagraph showing this lesion.

Apparently, Hecht's case of compound dislocation with fracture of the posterior part of the radial styloid also belongs in this class.

V. *Oblique and Upward and Forward.*—There are not a sufficient number of good specimens or records of this class of fracture to form a basis for conclusions as to its frequency. It has been assumed that forward displacement of the lower fragment implies such obliquity, but this seems to be by no means certain. Roberts has written an admirable monograph on the fracture with forward displacement, and has succeeded in collecting twenty-four clinical observations and thirty-one specimens classed as exhibiting this displacement. Unfortunately, the data in regard to some of these instances are rather defective, yet this form of the fracture is evidently less rare than has been supposed. Fig. 14 shows the writer's only case of this sort.

The only anatomical examination of an anterior displacement that the writer finds recorded is one by Lucas, not included in Roberts's series. This was a case of a woman of fifty-six who trod on her dress and fell forward onto the palms of both hands. On the right there was a simple Colles's fracture. The fracture on the left was compound, became septic, and had to be amputated. On dissection, the fracture line proved to be notably oblique upward and forward, but it is plainly to be seen from the excellent plate given that the forward displacement was but slight, the projection of the lower fragment anteriorly was largely due to the sharp rotation backward of the whole lower fragment. The deformity in life was that of the ordinary Colles's fracture.

Curiously enough, the two other specimens noted as showing obliquity of the fracture line in this reversed direction (Smith, specimen in Park Street School of Medicine, his Case II, and Flower, specimen in the Museum of the Royal College of Surgeons) do not show forward but backward displacement.

As to obliquity of the fracture upward and forward, it would seem, then, as if there were no connection between obliquity of the fracture upward and forward and the anterior displacement; nor can we say that the connection of this displacement with falls on the back of the hand is established. Cases of such falls are well attested in which fracture with ordinary backward displacement resulted (Cameron, Hamilton, Hennequin, Kahleyss), while two of Roberts's list of cases, with anterior displacement, seem to have been produced by falls on the palm.

For the present, then, one can hardly say more than that anterior displacement may occur, probably not so very rarely, that it may occur with fractures oblique in any direction, or transverse, including separations of the epiphysis (Roberts's Specimen I from the Mutter Museum, Denonvilliers, Péan, and Roux). It is probably usually, though certainly not always, a result of a fall on the dorsum of the hand. The dislocation of the ulna is back instead of forward. The ulnar styloid may be broken (Callender).

The type of fracture assumed by Barton to exist, the reverse of that usually known as Barton's fracture, a fracture, that is, involving only the anterior edge of the articular surface of the radius, may be produced experimentally, but hardly occurs during life. There seems to have been but one such specimen found, that of Letenneur cited by Stimson.

VI. *Fracture Oblique Upward and Outward.*—These are not infrequent, and occur as (*a*) fracture oblique upward and outward through the whole width of the bone; (*b*) fracture transverse towards the inner side trending up and out externally; (*c*) oblique fracture penetrating the joint.

Group (*a*) may be illustrated by the skiagraphs Figs. 15 and 16, and by the (united) museum specimen No. 2627 in the Museum of the School of Physic, Trinity College, Dublin, of which Roberts gives a plate. Group (*b*) is represented by Westbrook's specimen (see Fig. 18). Group (*c*) is illustrated by Hunt's case (see Fig. 20). In this group would also fall the specimen in the Mütter Museum numbered 1277, 65, described by Roberts, and Gordon's two specimens from the Museum of Queen's College in Belfast, his "third form" of fracture.

In all three groups there is likely to be much outward displacement and rotation, but not necessarily obliquity of fracture or displacement in either direction anteroposteriorly. In the last three cases cited there was displacement forward as well as outward. Other fractures of like direction, but detaching only the radial styloid, will be considered with the next group.

(TO BE CONTINUED.)